DCB/DCB

United States
Department of
Agriculture

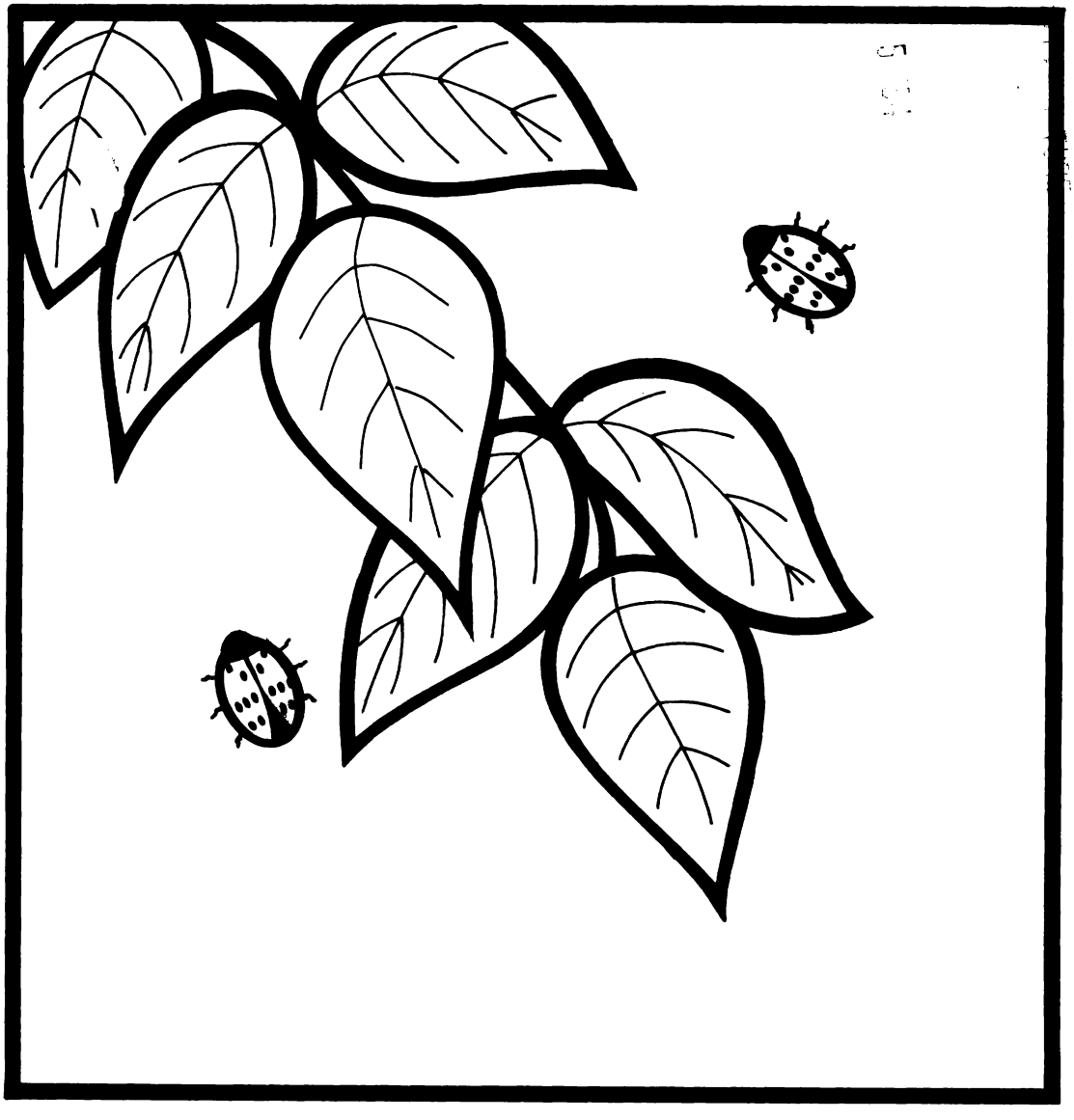
Economics,
Statistics, and
Cooperatives Service

Agricultural
Economic
Report No. 430-439
1979

Economic Feasibility of a Biological Control Technology

Using a Parasitic Wasp, Pediobius Foveolatus, to Manage Mexican Bean Beetle on Soybeans

by Katherine H. Reichelderfer



ECONOMIC FEASIBILITY OF A BIOLOGICAL CONTROL TECHNOLOGY: USING A PARASITIC WASP, PEDIOBIUS FOVEOLATUS, TO MANAGE MEXICAN BEAN BEETLE ON SOYBEANS, by Katherine H. Reichelderfer, Natural Resource Economics Division; Economics, Statistics, and Cooperatives Service; U. S. Department of Agriculture. Agricultural Economic Report No. 430.

ABSTRACT

Biological and conventional control can yield similar economic returns to pest control expenditures. Finding is based on economic feasibility study of using the parasitic wasp, Pediobius foveolatus, in place of conventional insecticides to control Mexican bean beetle on soybeans. Insect scouting in conjunction with use of the parasite is also compared with conventional control. Widespread use of the parasite to control the beetle could reduce use of insecticides without compromising soybean producers' revenues.

Keywords: Biological control, budget analysis, Mexican bean beetle, soybean pest control

CONTENTS

Washington, D. C. 20250 August 1979

SUMMARY

Mexican bean beetle control options include conventional chemical control and biological control by a parasitic wasp. Both options can yield similar returns to pest control expenditures on soybeans. Biological control, through an organized regional program, could reduce the impact of pesticides on the environment without hurting farm revenues.

Estimated profitability of biological control is highest in the Delmarva Peninsula (Delaware-Maryland-Virginia). The use of Pediobius foveolatus, a parasitic wasp, in conjunction with insect scouting to manage Mexican bean beetle on Delmarva soybeans, would lower insect control costs by an average, per treated acre, of $1.47. This would increase net revenue per soybean acre by $0.71 over that expected for conventional control. These estimates assume that biological control is equally as effective as use insecticides.

The Delmarva soybean grower could sustain a 0.21-bushel loss of soybeans per treated acre, given 1976 average soybean yield and price, without losing net revenue. The use of Pediobius plus scouting would compete with insecticide use to control Delmarva's Mexican bean beetle up to this loss point, assuming a yield change which is less than or equal to this 0.21-bushel break-even point.

Results vary among other regions. The break-even yield required to equalize soybean growers' average net revenue per expected acre treated biologically ranges from -0.21 (Delmarva) to +0.21 (North Carolina) bushels per acre change from the average yield obtained under conventional control. Biological control of the beetle on soybeans, supplemented by insect scouting, would be economical within this range.

Substitution of biological for conventional control of the Mexican bean beetle on soybeans would have little or no measureable effect on average U.S. soybean prices or the regional distribution of U.S. soybean production. Widespread adoption of this control technology would significantly reduce insecticide use on soybeans, but the value of the benefit of that reduction is unknown.

Economic Feasibility of a Biological Control Technology
Using a Parasitic Wasp, Pediobius foveolatus, to Manage Mexican Bean Beetle on Soybeans

Katherine H. Reichelderfer

INTRODUCTION

The economic feasibility of biological pest control is explored by this study. Biological control involves the conscious use of natural predators, parasites, or pathogens to suppress pest populations below levels causing economic damage. This study focuses on the Mexican bean beetle (MBB) on soybeans. The pest's biological control by a parasitic wasp is compared with insecticidal control.

Insecticide use on soybeans has been small relative to crops such as cotton where chemicals are applied with great intensity. Almost 7.9 million pounds (a.i.) of insecticide were applied to soybeans in 1976 (6), costing about $13 million (5). 1/ In contrast, over 64 million pounds (a.i.) were applied to cotton (6).

The State of Maryland has recently funded a biological control program aimed at the suppression of MBB, the State's primary soybean insect pest. This method involves annual regional distribution of a parasitic wasp, Pediobius foveolatus, a natural enemy of the MBB. The wasp has been successfully used in Maryland's Delmarva Peninsula (4) and in South Carolina (3). Maryland aims to provide regional nonchemical MBB control so that insecticide use on soybeans declines and soybean production cost savings are realized. The University of Delaware has conducted a similar program, still experimental.

There are four objectives of the present study:

(1) To determine whether or not longrun production cost savings can be expected to accrue to soybean growers in the Delmarva Peninsula who use Pediobius foveolatus to control MBB.

(2) To estimate the growers' expected value of production cost savings and change in net revenue.

(3) To evaluate the economic feasibility of using Pediobius foveolatus to manage MBB throughout all U.S. soybean production areas in which that insect is the primary pest of soybeans.

(4) To estimate the change (if any) in average U.S. soybean price that could be expected to result from wide adoption of the MBB biological control technology.

1/ Underscored numerals in parentheses cite items in References section.

BACKGROUND

Total U.S. soybean production more than doubled between 1960 and 1976 and the real value of that production increased by over 365 percent (7). Soybean production increased the most rapidly during this period in the Southeast and Delta States. The Corn Belt leads in soybean acreage (table 1).

U.S. soybean producers face a variety of soybean pests. At least 10 grass species and 15 broadleaf weeds compete with soybeans for nutrients and light. Twenty-one infectious soybean diseases have been identified although few have ever developed to epidemic proportions. At least 25 insect species may be classified as major pests of soybeans; three of the most significant defoliators are the MBB, the velvet bean caterpillar, and the green cloverworm. The relative importance of each varies among production regions (fig.1).

Insect pest problems on soybeans are less severe than on other major crops such as corn and cotton. Soybean losses to insects, with current controls, have averaged 3 percent of potential production (9). "As soybeans are planted on increased acreages and introduced into new areas," notes one study, "new insect problems continually emerge." Estimates in that study indicate a potential loss of soybeans to insects in the Corn Belt ranging between 11 and 35 percent (1).

Pesticide use has risen with the increasing severity of insect pest problems on soybeans. USDA estimates that 5.7 million pounds of insecticides were applied to soybeans in 1971 and 7.9 million pounds were applied in 1976 (6). A portion of this 38-percent increase is due to increased soybean acreage.

MBB and velvet bean caterpillar control account for 7 and 34 percent, respectively, of total insecticides used on soybeans in 1976 (table 2). The proportion of acres treated by each major type of insecticide used against each target pest on soybeans in 1976 is also noted in table 2.

Farmers spent an average of $0.26 per harvested soybean acre for insecticides and their application in 1976. Insecticide costs and the intensity of their use vary among regions (table 3). The Firm Enterprise Data System (FEDS) 2/ areas cited in table 3 are illustrated in figure 2. The areas were chosen as examples because they roughly correspond with the areas identified in figure 1 as ones in which MBB is the primary insect pest of soybeans.

MEXICAN BEAN BEETLE CONTROL IN DELMARVA

Delmarva soybean growers have a number of different methods by which to control MBB populations. These include biological control by a parasitic wasp, various patterns of chemical control, including prescribed spraying pest management, and a strategy which integrates the use of both.

2/ FEDS is a set of enterprise budgets that represent a majority of production in primary agricultural regions. Budget generation was developed at Oklahoma State University and has been adapted by that institution, in cooperation with the National Economics Division of USDA's Economics, Statistics, and Cooperative Service, for use in addressing agricultural policy issues.

Table 1--Soybean acreage and production, 1978

Region and State	Acreage	Production
	1,000 acres	1,000 bushels
Northeast	880	26,539
New York	22	506
New Jersey	206	6,180
Pennsylvania	62	1,953
Delaware	245	6,860
Maryland	345	11,040
Appalachian	5,825	148,830
Virginia	445	12,460
Tennessee	2,420	56,870
Kentucky	1,410	42,300
North Carolina	1,550	37,200
Southeast	5,500	114,240
South Carolina	1,470	32,340
Georgia	1,680	29,400
Alabama	1,950	42,900
Florida	400	9,600
Delta	11,340	265,500
Mississippi	3,800	81,700
Louisiana	2,840	71,000
Arkansas	4,700	112,800
Southern Plains	1,060	24,725
Texas	745	19,370
Oklahoma	315	5,355
Corn Belt	30,060	1,009,380
Missouri	5,440	155,040
Iowa	7,550	286,900
Illinois	9,190	303,270
Indiana	4,130	140,420
Ohio	3,750	123,750
Northern Plains	3,263	85,253
Kansas	1,450	26,100
Nebraska	1,250	42,500
South Dakota	390	11,895
North Dakota	173	4,758
Lake States	5,075	168,180
Minnesota	4,060	142,100
Wisconsin	215	6,880
Michigan	800	19,200
U.S. total	63,003	1,842,647

Source: U.S. Department of Agriculture; Economics, Statistics, and Cooperatives Service; Crop Reporting Board. Crop Production, 1978 Annual Summary. CrPr 2-1 (79), Jan. 1979.

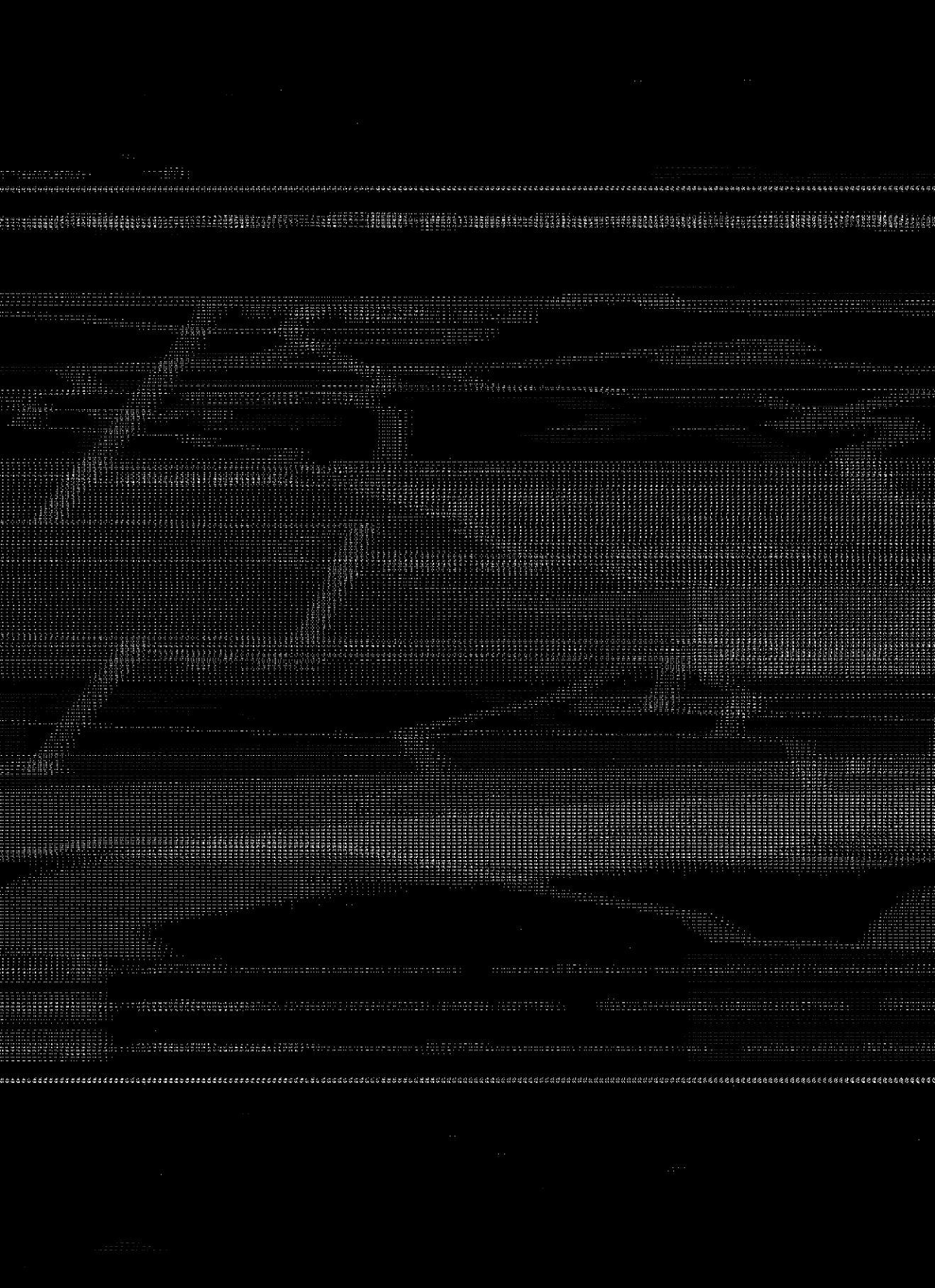


Table 2--Insecticides on soybeans: Amount used and proportion of acres treated, by various chemicals and target pests, 1976

Pest	Unit	Carbaryl	Toxaphene	Methyl parathion	Methomyl	Parathion	Disulfoton	All others	Total
Mexican bean beetle:									
Amount	1,000 lbs.	168.5	66.2	14.3	62.8	--	220.0	15.5	547.3
Proportion of acres	Pct.	29	4	4	26	--	31	6	100
Velvetbean caterpillar:									
Amount	1,000 lbs.	2,089	485.5	114.1	4.8	--	--	--	2,693.4
Proportion of acres	Pct.	86	7	7	1/	--	--	--	2/ 100
Army worm:									
Amount	1,000 lbs.	337	287	71.3	154.6	--	7.0	103.5	960.4
Proportion of acres	Pct.	24	8	8	36	--	1	23	100
Cabbage looper:									
Amount	1,000 lbs.	438	706.2	171.1	154.6	21.9	--	--	1,491.8
Proportion of acres	Pct.	24	25	24	25	3	--	--	2/ 100
Stink bug:									
Amount	1,000 lbs.	34	640	306.6	29	50.1	--	1.5	1,061.2
Proportion of acres	Pct.	7	31	48	10	4	--	--	2/ 100
Corn earworm:									
Amount	1,000 lbs.	101.1	--	35.7	58.0	122.1	--	--	316.9
Proportion of acres	Pct.	16	--	8	22	52	--	2	100
All others:									
Amount	1,000 lbs.	201.4	22.1	--	19.2	118.9	7.0	427.5	796.1
Proportion of acres	Pct.	43	--	1/	6	38	1	10	2/ 100

-- = No significant use.
1/ Less than 1.0 percent.
2/ Does not add to 100 due to rounding errors.

Source: 1976 National Pesticide Use Survey, U.S. Dept. Agr., Econ. Stat. Coop. Serv., prelim. data, Nov. 1977.

Table 3—Range of insect control costs in soybean production, by selected area, 1976

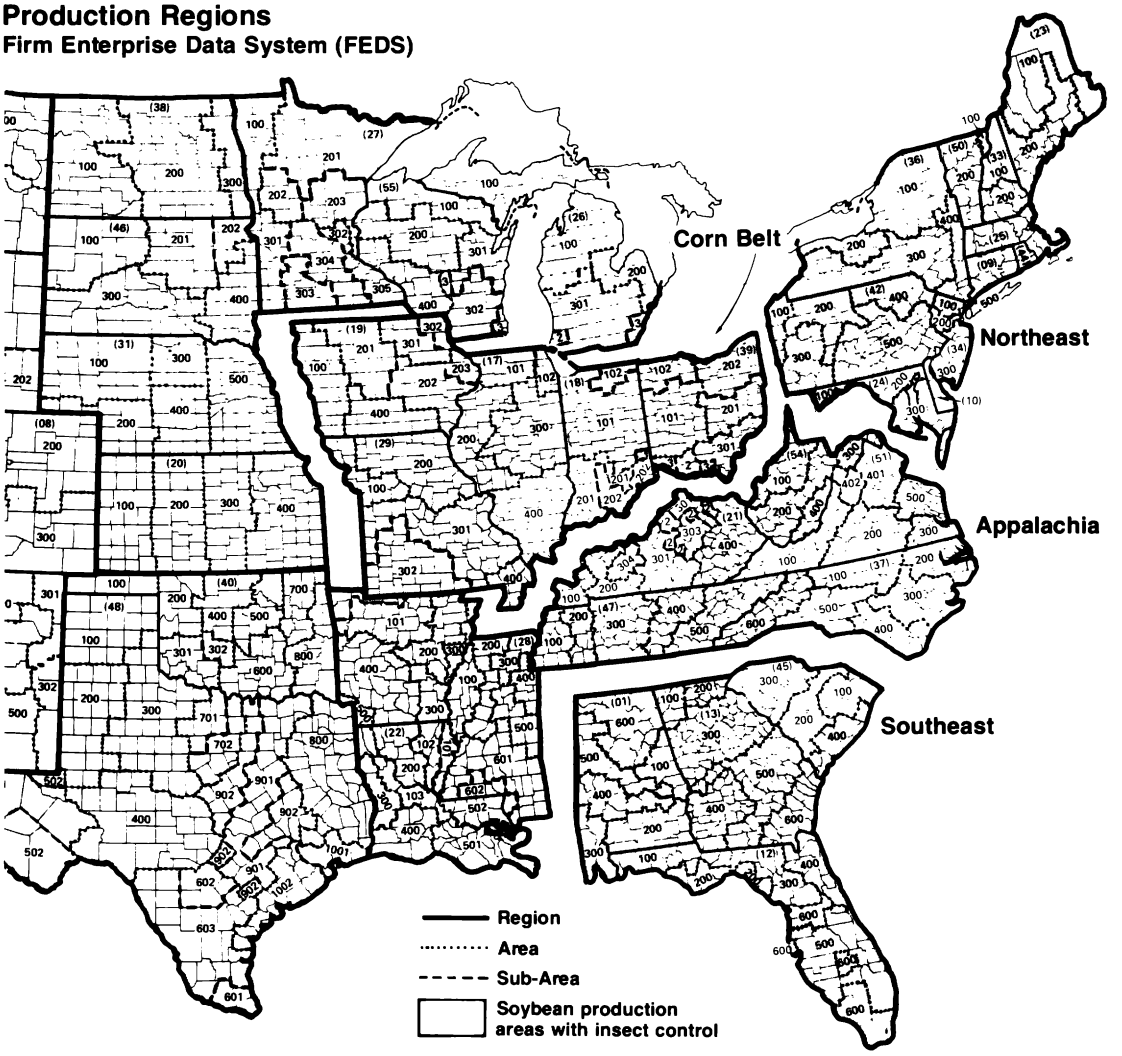
State	FEDS area	Area represented	Yield	Insecticide: Cost per acre	Insecticide: Proportion of acres 1/	Application: Cost per acre	Application: Proportion of acres 1/	Total insect control cost	Total variable cost (TVC)	Insect control as proportion of TVC	Insect control cost per bushel
		1,000 acres	Bu./ acre	Dols.	Pct.	Dollars	Pct.	Dollars per acre		Pct.	Dollars
Kentucky	100 and 200	943.3	23.7	0	0	0	0	0	47.47	0	0
Illinois	400	2,171.5	27.1	2.50	2	2.00	2	0.09	45.05	2/	3/
New Jersey	Southern	76.4	23.7	2.85	10	2.75	2	0.33	72.05	2/	0.01
New Jersey	Central	27.7	22.4	2.85	10	2.75	2	0.33	71.70	2/	0.01
Delaware	Entire State	185.0	23.6	2.85	15	0	0	0.43	63.20	2/	0.02
Indiana	200	639.3	32.3	2.40	13	2.28	8	0.49	46.01	1.1	0.02
Kentucky	300	152.2	25.1	3.90	9	4.75	6	0.63	41.27	1.5	0.02
Maryland	Northern	17.6	23.2	2.85	20	2.75	3	0.65	64.65	1.0	0.02
Maryland	Southern	272.4	24.7	2.85	20	2.75	3	0.65	64.11	1.0	0.02
South Carolina	200	517.7	16.5	2.70	22	2.65	22	1.17	59.03	2.0	0.08
South Carolina	300	165.0	16.2	2.70	22	2.65	22	1.17	57.78	2.0	0.08
South Carolina	100	464.9	18.7	2.70	34	2.65	13	1.26	58.61	2.1	0.07
North Carolina	400	221.5	19.1	4.10	37	0	0	1.52	64.11	2.4	0.08
North Carolina	100 and 500	315.2	14.1	4.10	38	2.65	7	1.75	50.77	3.4	0.11
Virginia	Entire State	408.8	19.9	5.25	34	0	0	1.78	64.20	2.8	0.09
North Carolina	300	390.7	20.7	4.10	41	2.65	7	1.87	55.14	3.4	0.09
North Carolina	200	265.9	25.5	4.10	66	2.65	9	2.95	60.90	4.8	0.12

1/ Proportion of total soybean acres in area receiving insecticides.
2/ Less than 1 percent.
3/ Less than 1 cent per bushel.

Source: 1976 Firm Enterprise Data System (FEDS) budgets, U.S. Dept. Agr., Econ. Stat. Coop. Serv.

Figure 2

Production Regions
Firm Enterprise Data System (FEDS)



Chemical Control

Two insecticides are commonly used, either singly or in combination, to control MBB on soybeans in Delmarva. Disulfoton, a systemic insecticide, is frequently utilized as a prophylactic control measure. Carbaryl is used on a scheduled basis, as its need is assessed by individual producers, or as a component of a prescribed spraying strategy. It is usually aerially applied in Delmarva. A single seasonal application of one of these two insecticides, or of another, is the common treatment on those Delmarva soybean acres which are treated. The timing of application and number of acres treated, however, vary according to the level of MBB infestation experienced in a given year.

The following probabilities are associated with MBB infestation levels and percentage of acres treated with a single foliar application of insecticides (8):

Infestation level	Probability of occurrence	Percent of acres treated foliarly
	Percent	
Limited	30	10
Normal	60	29
Extensive	10	43

This shows, for example, that there is a 10-percent chance that there will be an extensive MBB infestation, and that when infestation is extensive, 43 percent of total soybean acreage receives foliar insecticide treatment. The expected percentage of acres typically treated with a single application of carbaryl or another foliar insecticide is an additive function of the probability of occurrence of each infestation level times the percentage of acres treated when that level is achieved. It equals: (.3)(10) + (.6)(29) + (.1)(43) or 24.7 percent of Delmarva soybean acreage. This means that, during the average growing season, 24.7 percent of total acreage is treated with a foliar insecticide. Carbaryl is the primary material used.

In addition to carbaryl treatment, soybeans are treated with systemic insecticides. Thirty percent of double-cropped soybean acreage (18 percent of total Delmarva soybean acreage) is typically treated with disulfoton, a systemic. Since disulfoton is used as a preventative treatment, its use cannot be predicted on the basis of MBB infestation level. The average, longrun expected percentage of acres treated, with one type of insecticide or the other, for MBB control equals 24.7 (average percentage of acreage treated by foliar insecticide) plus 18.0 (percentage of acreage treated by systemic insecticide), or 42.7 percent of Delmarva soybean acres.

Biological Control

The Pediobius foveolatus wasp is unable to overwinter in temperate zones and must be released annually. Its mode of action is oviposition into second and later instar MBB larvae. The parasite is specific to MBB.

The use of Pediobius populations to control MBB on soybeans in Delmarva was first tested during 1972 to 1974. Use of the parasite was subsequently incorporated into the University of Maryland Soybean Pest Management Program. Adult wasps are released each year into strategically placed nurse plots of early growing garden variety beans on

which early MBB populations are developing. The wasp population expands in the nurse plots and migrates into neighboring soybean fields when a sufficient MBB population is available there for parasitization. If necessary, wasps are manually placed in hot spots of MBB activity on soybeans.

The Maryland State Department of Agriculture began financing the rearing and distribution of Pediobius in 1976. The fixed, capital costs of rearing the parasite were estimated at $3,860 (2). Assuming a 12-percent discount rate over a 20-year period, annual ammortized fixed costs equal $516.66. Annual operating costs of the biological control program totaled $41,492.30 for 1976 and 1977. This figure includes costs of materials and transportation, the salaries of two full-time employees, wages for temporary help in distributing the parasite, various contractual services, the value of 20 percent of one scientist man-year, and the value of 240 agricultural extension agent man-hours. The 1977 Maryland target acreage for biological control was 30,000 acres. Therefore, the total annual public cost of biological control equals $1.40 per acre treated. In conjunction with public funding of the biological control program, nurse plots are voluntarily donated, at a cost of approximately $50.00 per plot, by soybean growers recruited by Maryland agricultural extension agents. Over 200 nurse plots were provided by growers in 1977.

Integrated Control

Insect scouting is used in conjunction with biological control under the Maryland Soybean Pest Management Program. This program monitors the efficacy of the Pediobius populations and indicates when supplemental parasite releases or chemical control action might be needed. A USDA Extension Service (now Science and Education Administration) pilot pest management grant provided funds for scouting personnel from 1975 to 1977. These funds since 1978 have been provided by soybean grower participants at $1.50 per acre.

Control Costs

Table 4 summarizes the per acre MBB control costs attached to alternative control actions. Roughly 25 percent of Delmarva soybean acreage is treated during the average season. The proportion of those acre treatments receiving carbaryl application is 57.8 percent. The remaining 42.2 percent of acre treatments are of disulfoton. The average cost per conventionally treated acre in Delmarva may be calculated as: (.578) ($5.27) + (.422) ($3.73) = $4.62 (from table 4). Cost savings per treated acre of substituting biological for conventional control can be expected to equal $2.97, if biological control is the sole action taken, or $1.47 if biological control is supplemented by insect scouting services.

Under biological control, average Delmarva soybean yield per acre would have to decrease by 0.43 3/ bushels per acre (0.21 bushels per acre for biological control plus insect scouting) before conventional control would be a better revenue producer. This means that the Delmarva soybean grower can sustain an average 2-percent yield loss and still break even when biological control is substituted for conventional MBB control. This indicates that biological control is a competitive MBB control on

3/ A cost savings of $2.97 is equivalent to the value of 0.43 bushel of soybeans at the soybean price of $6.87 per bushel.

Table 4—Mexican bean beetle control costs in Delmarva

Type of control	Cost
Conventional control: 1/	Dollars per acre
Carbaryl—	
1 pound	2.52
Aerial application	2.75
Total	5.27
Disulfoton--	
1 pound a.i. applied at planting	3.73
Biological control: 2/	
Establishment of nurse plot at cost of $50 per 200 acres	.25
Rearing and distribution of Pediobius foveolatus	1.40
Total	1.65
Biological control plus insect scouting:	
Biological	1.65
Scouting	1.50
Total	3.15

1/ Control actions and costs per treated acre are identical over all expected levels of MBB infestation. The percentage of total acres treated varies by level of regional pest infestation while average treatment per acre does not.

2/ Determination of the total cost of biological control per biologically treated acre was made under the assumptions that the group of individual soybean growers in Delmarva collectively pay for the release and distribution of Pediobius and that the group can finance annual biological control requirements with equal efficiency as does the State of Maryland currently.

Delmarva treated soybean acreage, assuming use of Pediobius is at least 98 percent as efficacious as conventional chemical treatment.

FEASIBILITY OF BIOLOGICAL CONTROL IN DELMARVA

Costs detailed in table 4 apply to treated acres only. Not all Delmarva soybean acreage is treated each year. The average Delmarva soybean acre, then, would receive a benefit equal to less than the simple difference between conventional and biological control costs.

Tables 5, 6, and 7 are soybean production budgets constructed according to the type of control action taken on the representative Delmarva soybean acre. Table 5 includes the costs of conventional control of Mexican bean beetle and the expected percentage of acres treated with carbaryl and disulfoton. Tables 6 and 7 are identical except that biological control is assumed to be substituted for insecticide usage on the same proportion of acres. Yield per acre was assumed to remain constant, given the substitution of biological for chemical control on that acreage. The difference in average net revenue to the representative soybean grower (line 9) of utilizing biological instead of chemical control is $1.37 (or $0.71 for biological control plus insect scouting) per average soybean acre.

The average yield loss that could be sustained without a loss of net revenue by the representative Delmarva soybean grower, given a substitution of biological for conventional MBB control is approximately 0.20 4/ bushel per acre (0.10 bushel per acre for biological control plus insect scouting services). Assuming that biological control can prevent all but that minor yield loss to the pest, average returns to soybean production in Delmarva would not be expected to decrease, given a switch from convention to biological control. Under that assumption, budget analysis results indicate that biological MBB control in Delmarva is competitive with the use of insecticides.

FEASIBILITY OF BIOLOGICAL CONTROL IN OTHER REGIONS

Budget analysis indicates that substitution of biological or integrated control for conventional control may be feasible in all areas where MBB is the major insect pest of soybeans. The potential profitability of biological control varies by soybean production region. In no other region is it as great as it is for Delmarva.

Recommended or conventional MBB control actions (type of chemical employed, rate of application) and the proportion of acres typically treated vary among regions in which MBB is the primary soybean insect pest. Therefore, one cannot assume that the use of Pediobius would be as competitive with conventional control in all soybean production regions as was estimated for Delmarva.

Estimation of the difference in average net revenue per treated soybean acre in each of five production regions was made under the following assumptions:

1) Costs of biological control are the same in all regions as they are in Delmarva.

2) All acres conventionally treated within a given region receive the most typical MBB control action reported by the Dimilin Assessment Team (8) for that region.

3) The proportion of soybean acres treated that receive custom application in a given region is that proportion reported in the 1976 FEDS budgets.

The first assumption may not reflect reality. Economies of scale may be realized in the transfer of the biological control technology from Delmarva to regions in which the average soybean acreage planted is larger than that in Delmarva. However, in

4/ Twenty percent of a bushel of soybeans, at soybean price of $6.87 per bushel, is equal in value to the $1.37 cost savings per representative acre.

Table 5--Soybean production budget for Delmarva: Conventional insect control 1/

Budget item	Unit	Quantity per acre	Price or cost per unit	Value or cost per acre	Cost per unit of production
				Dollars	
1. Gross receipts from production:					
Soybean	Bu.	22.200	6.870	152.51	
Total receipts				152.51	
2. Variable costs:					
Preharvest--					
Grain seed	Lbs.	61.900	0.107	6.62	0.30
Nitrogen	do.	12.060	.206	2.48	.11
Phosphate	do.	38.420	.177	6.80	.31
Potash	do.	50.030	.101	5.05	.23
Herbicide	Acre	2/ .800	9.539	7.63	.34
Insecticide	do.	2/ .427	3.030	1.29	.06
Herbicide application	do.	2/ .100	2.750	.27	.01
Insecticide application	do.	2/ .277	2.750	.76	.03
Fertilizer application	do.	.099	3.000	.30	.01
Lime	Ton	.344	13.810	4.75	.21
Tractor fuel and lube	Acre			2.48	.11
Tractor repairs	do.			1.12	.05
Equipment fuel and lube	do.			1.81	.08
Equipment repairs	do.			1.82	.08
Machinery labor	Hrs.	3.950	2.420	9.56	.43
Interest on operating capital	Dols.	22.605	.083	1.88	.08
Total preharvest				54.63	2.46
Harvest--					
Custom combining	Acre	.128	13.250	1.70	.08
Custom hauling	Hrs.	.700	8.000	.56	.03
Equipment fuel and lube	Acre			1.65	.07
Equipment repairs	do.			2.64	.12
Machinery labor	Hrs.	1.084	2.420	2.62	.12
Interest on operating capital	Dols.	.000	.083	.00	.00
Total harvest				9.17	.41
Total variable costs				63.80	2.87
3. Income above variable costs				88.71	4.00
4. Ownership costs (depreciation, taxes, interest, insurance):					
Tractors				5.58	0.25
Machinery and equipment				21.22	0.96
Total ownership costs				26.80	1.21
5. Return to land, overhead, risk, and management				61.91	2.79
6. Land charge				.00	.00
7. Management charge (7% of gross receipts)				10.68	.48
8. Total of above costs				101.28	4.56
9. Return to overhead and risk				51.23	2.31

1/ This budget represents a weighted average of the 1976 FEDS budgets for Delaware, Maryland, and Virginia. Acres represented by budget: 883,800 acres.
2/ Proportion of acres treated.

Source: (5).

Table 6--Soybean production budget for Delmarva: Biological insect control 1/

Budget item	Unit	Quantity per acre	Price or cost per acre	Value or cost per acre	Cost per unit of production
				Dollars	
1. Gross receipts from production:					
Soybeans	Bu.	22.200	6.870	152.51	
Total receipts				152.51	
2. Variable costs:					
Preharvest--					
Grain seed	Lbs.	61.900	0.107	6.62	0.30
Nitrogen	do.	12.060	.206	2.48	.11
Phospate	do.	38.420	.177	6.80	.31
Potash	do.	50.030	.101	5.05	.23
Herbicide	Acre	2/ .800	9.539	7.63	.34
Herbicide application	do.	2/ .100	2.750	.27	.01
Fertilizer application	do.	.099	3.000	.30	.01
Lime	Ton	.344	13.810	4.75	.21
Nurse plot	Acre	2/ .427	.250	.11	.00
Pediobius	do.	2/ .427	1.400	.60	.03
Tractor fuel and lube	do.			2.48	.11
Tractor repairs	do.			1.12	.05
Equipment fuel and lube	do.			1.81	.08
Equipment repairs	do.			1.82	.08
Machinery labor	Hrs.	3.950	2.420	9.56	.43
Interest on operating capital	Dols.	22.415	.083	1.88	.08
Total preharvest				53.27	2.40
Harvest--					
Custom combining	Acre	.128	13.250	1.70	.08
Custom hauling	Hrs.	.070	8.000	.56	.03
Equipment fuel and lube	Acre			1.65	.07
Equipment repairs	do.			2.64	.12
Machinery labor	Hrs.	1.084	2.420	2.62	.12
Interest on operating capital	Dols.	.000	.083	.00	.00
Total harvest				9.17	.41
Total variable cost				62.44	2.81
3. Income above variable costs				90.08	4.06
4. Ownership costs (depreciation, taxes, interest, insurance):					
Tractors				5.58	.25
Machinery and equipment				21.22	.96
Total ownership costs				26.80	1.21
5. Return to land, overhead, risk, and management				63.27	2.85
6. Land charge				.00	.00
7. Management charge (7% of gross receipts)				10.68	.48
8. Total of above costs				99.92	4.50
9. Return to overhead and risk				52.60	2.37

1/ Assumes substitution of biological control only treated acreage. Acres represented by budget: 883,800 acres.
2/ Proportion of acres treated.

Source: (5).

Table 7--Soybean production budget for Delmarva: Biological insect control in conjunction with scouting activities 1/

Budget item	Unit	Quantity per acre	Price or cost per acre	Value or cost per acre	Cost per unit of production
				Dollars	
1. Gross receipts from production:					
Soybeans	Bu.	22.200	6.870	152.51	
Total receipts				152.51	
2. Variable costs:					
Preharvest--					
Grain seed	Lbs.	61.900	0.107	6.62	0.30
Nitrogen	do.	12.060	.206	2.48	.11
Phospate	do.	38.420	.177	6.80	.31
Potash	do.	50.030	.101	5.05	.23
Herbicide	Acre	2/ .800	9.539	7.63	.34
Herbicide application	do.	2/ .100	2.750	.27	.01
Fertilizer application	do.	.099	3.000	.30	.01
Lime	Ton	.344	13.810	4.75	.21
Nurse plot	Acre	2/ .427	.250	.11	.00
Pediobius	do.	2/ .427	1.400	.60	.03
Check for insects	do.	2/ .427	1.500	.64	.03
Tractor fuel and lube	do.			2.48	.11
Tractor repairs	do.			1.12	.05
Equipment fuel and lube	do.			1.81	.08
Equipment repairs	do.			1.82	.08
Machinery labor	Hrs.	3.950	2.420	9.56	.43
Interest on operating capital	Dols.	22.602	.083	1.88	.08
Total preharvest				53.93	2.43
Harvest--					
Custom combining	Acre	.128	13.250	1.70	.08
Custom hauling	Hrs.	.070	8.000	.56	.03
Equipment fuel and lube	Acre			1.65	.07
Equipment repairs	do.			2.64	.12
Machinery labor	Hrs.	1.084	2.420	2.62	.12
Interest on operating capital	Dols.	.000	.083	.00	.00
Total harvest				9.17	.41
Total variable cost				63.09	2.85
3. Income above variable costs				89.42	4.02
4. Ownership costs (depreciation, taxes, interest, insurance):					
Tractors				5.58	.25
Machinery and equipment				21.22	.96
Total ownership costs				26.80	1.21
5. Return to land, overhead, risk, and management				62.48	2.81
6. Land charge				.00	.00
7. Management charge (7% of gross receipts)				10.68	.48
8. Total of above costs				100.58	4.54
9. Return to overhead and risk				51.94	2.33

1/ This budget represents a weighted average of the 1976 FEDS budgets for Delaware, Maryland, and Virginia. Acres represented by budget: 883,800 acres.

2/ Proportion of acres treated.

Source: (5).

regions where the average contiguous set of soybean acreage is large, scouting costs per acre may be greater than in Delmarva.

Average control cost per acre treated conventionally for the MBB, by region, was calculated from the table 8 data and is shown in table 9 along with the constant (by assumption) cost per acre of biological control. Biological control plus scouting costs per acre exceed average conventional control costs per acre in only one area--North Carolina.

Table 10 shows total costs and net revenues for the same regions under the three MBB control scenarios--conventional, biological, and biological plus scouting. Table 10 also shows the break-even yield change for the average treated acre in each region. This change is the quantity of soybeans per acre that equals in value, and thus offsets the change in the cost of MBB control associated with a switch from conventional to biological control. If the exact break-even yield change occurred when a grower switched from conventional to biological control, his net revenue would be unchanged. The estimated break-even yield change for biological control and insect scouting service ranges from -0.21 to 0.21 bushels of soybeans per acre. At 1976 average prices, Delmarva growers could sustain a 0.2-bushel-per-acre yield loss, but North Carolina soybean growers would have to realize a 0.2-bushel-per-acre increase in yield for the the use of biological MBB control and scouting services to be as profitable as conventional control.

A fifth of a bushel of soybeans represents less than 2 percent of the average yield per acre. This percentage change in yield is well within normal deviations expected between years or between acres.

Under all of the assumptions cited above, and given the minor break-even yield changes estimated at either end of the range throughout regions, the use of Pediobius is competitive, to varying degrees, in all regions in which the MBB is the primary soybean pest.

SECONDARY ECONOMIC IMPACTS

Substitution of biological for conventional MBB control will not have a significant impact on average soybean prices received by farmers. The 514,300 expected acres treated for MBB in the regions identified in tables 8, 9, and 10 comprise 10.2 percent of total U.S. soybean acreage (7). The weighted average cost per treated acre estimated to result from a change to biological control and insect scouting equals $1.19 per acre. The estimated average change in production cost per U.S. acre, given the change in control practice, equals: (-1.19) (0.102) = -$0.12. As U.S. average soybean yield per acre equaled 25.6 bushels in 1976 (7), the 12-cent decrease in average per acre cost of production represents an average cost savings of approximately one half cent per bushel. This change could have a measurable but slight effect on average soybean price.

Changes in production costs and net revenue caused by the substitution of biological for conventional MBB control may affect the attractiveness of soybeans relative to other crops. Widespread adoption of biological control could affect the competitive advantage or disadvantage that certain soybean production regions maintain relative to others. For example, it was estimated that Delmarva's average soybean production costs would decrease by from $0.71 to $1.37 per acre. Given a fairly fixed soybean price received, the reduction in costs could give Delmarva a competitive advantage over other regions or could minimize its disadvantage relative to regions in which production

Table 8--Most typical Mexican bean beetle treatment, proportion of acre treatments custom applied, and costs by region

Region	Most typical treatment, one application	Material cost per treated acre	Proportion of acres custom treated	Custom application
	Pounds	Dollars per acre	Percent	Dollars per acre
Delmarva	1.0 carbaryl or disulfoton	3.03	57.8	2.75
New Jersey	1.0 carbaryl or disulfoton	3.03	57.8	2.75
IL-IN-KY 1/	0.75 carbaryl	1.89	84.4	2.64
South Carolina	0.5 carbaryl	1.26	74.5	2.65
North Carolina	0.5 carbaryl	1.26	16.6	2.65

1/ Includes Illinois FEDS area 400, Indiana FEDS area 200, and Kentucky FEDS areas 100, 200, and 300 (5).

Sources: "Most typical treament" -- (8).
"Average custom application cost" -- (5).

Table 9--Mexican bean beetle control costs per treated acre by region

Item	Delaware	New Jersey	IL-IN-KY 1/	South Carolina	North Carolina
			1,000 acres		
Total acres 2/	883.8	104.1	3,906.3	1,147.6	1,193.3
Acres treated 3/	377.4	44.5	10.0	65.9	16.5
			Dollars per acre		
Treatment costs:					
Conventional 4/	4.62	4.62	4.12	3.25	1.70
Biological	1.65	1.65	1.65	1.65	1.65
Biological plus scouting	3.15	3.15	3.15	3.15	3.15
Cost difference between--					
Biological and conventional	2.97	2.97	2.47	1.60	0.05
Biological plus scouting and conventional	1.47	1.47	0.97	0.10	-1.45

1/ Includes Illinois FEDS area 400, Indiana FEDS area 200, and Kentucky FEDS areas 100, 200, and 300.
2/ From the 1976 FEDS budgets (see 5).
3/ Expected percentage acres treated (Dimilin Assessment Team) X total acres (FEDS).
4/ Average cost of materials and application.

Table 10--Total soybean production costs and net revenue per treated acre, by MBB control method and region

Item	Delmarva	New Jersey	IL-IN-KY 1/	South Carolina	North Carolina
			Bushels per acre		
Average yield 2/	22.20	23.35	27.04	17.35	19.81
			Dollars per bushel		
Average soybean price 2/	6.87	7.50	7.46	7.25	7.00
			Dollars per acre		
Average value per acre	152.51	175.16	201.72	125.77	138.66
Conventional treatment:					
Total production cost	103.85	114.99	160.64	119.05	127.84
Average net revenue	48.66	60.17	41.08	6.72	10.82
Biological treatment:					
Total production cost	100.88	112.02	158.17	117.45	127.79
Average net revenue	51.63	63.14	43.55	8.32	10.87
Biological plus scouting treatment:					
Total production cost	102.38	113.52	159.67	118.95	129.29
Average net revenue	50.13	61.64	42.05	6.82	9.37
Difference in net revenue:					
Biological minus conventional	2.97	2.97	2.47	1.60	.05
Biological plus scouting minus conventional	1.47	1.47	.97	.10	-1.45
			Bushels per acre		
Break even yield change:					
Conventional vs. biological 3/	- .43	- .40	- .33	- .22	.00
Conventional vs. biological plus scouting 3/	- .21	- .19	- .13	.00	+ .21

1/ Includes Illinois FEDS area 400, Indiana FEDS area 200, Kentucky FEDS areas 100, 200, and 300.
2/ From the 1976 FEDS budgets (see 5).
3/ Change in soybean yield that would equalize net revenue per acre treated conventionally and biologically.

costs are very low. A positive change in relative advantage could stimulate increased production of soybeans in the region experiencing the benefit, or could prevent or slow an observed trend of soybean disappearance from an area.

The distributional and crop-mix impacts of a change from conventional to biological MBB control would be minimal. The average difference in soybean insect control costs represents, in each region considered, less than 2 percent of total production costs. Cost changes of such small magnitude as this are not likely to result in significant changes in the distribution of soybean production nationwide. Nor should they impact heavily on the relative proportion of soybeans produced in the United States.

IMPACTS ON PESTICIDE USE

The substitution of biological control for the most typical conventional control treatment on all expected soybean acres treated would reduce insecticide use on soybeans by approximately 177,800 pounds (a.i.) of disulfoton and 336,400 pounds (a.i.) of carbaryl per year. Environmental effects of the insecticides' use would decline and the producers of the chemicals could experience an initial loss of revenue.

Potential environmental effects of the use of carbaryl include the destruction of honey bees, fish, and other nontarget species. As carbaryl usage is decreased, the frequency of occurrence and severity of such adverse effects should also decrease. It is difficult to estimate the value of a reduction in environmental impacts. Some benefit in terms of environmental quality should accrue, however, from the substitution of biological for conventional MBB control.

Continued use of insecticides may allow development of pest populations resistant to frequently used chemicals. And, if beneficial insect species are killed by the insecticides, secondary pest outbreaks could occur. As insecticide use declines, the rate of development of resistance should also decline, as would the frequency of secondary pest outbreaks.

The estimated decrease in insecticide use on soybeans would have only a minor effect on chemical producers. Such insecticides, in the amount used on soybeans, represent only a small portion of the total produced. They constitute less than 4 percent of carbaryl and disulfoton applied in the United States (6).

CONCLUSION

Biological MBB control by Pediobius is, to varying degrees, an economically feasible alternative to conventional control in every region in which the MBB is the major insect pest of soybeans. An organized public or cooperative effort is necessary for its widespread adoption. Only small positive or negative changes in soybean farmers' net revenues would occur if biological or integrated control were substituted for conventional control of the pest. A switch from chemical to biological or integrated MBB control could reduce the environmental load of pesticides and maintain average soybean producers' income.

REFERENCES

1. National Academy of Sciences. Pest Control: An Assessment of Present and Alternative Technologies, Vol. II - Corn/ Soybeans Pest Control. Washington, D.C., 1975.

2. Reichelderfer, Katherine H. "A Simulative Approach to the Comparison of Alternative Methods for the Control of Mexican Bean Beetle on Soybeans." Unpublished doctoral dissertation, University of Maryland, Dec. 1977.

3. Shepard, Merle, and John Robinson. "Suppression of Mexican Bean Beetles in Soybean by the Imported Parasite, Pediobius foveolatus," Department of Entomology and Economic Zoology, Clemson University, 1978.

4. Stevens, L.M., A.L. Steinhauer, and J.R. Coulson. "Suppression of Mexican Bean Beetle on Soybeans with Annual Inculative Releases of Pediobius foveolatus," Environ. Entomol., Dec. 1975: 947-952.

5. U.S. Department of Agriculture. "1976 Firm Enterprise Data System Crop Budgets," Econ. Stat. Coop. Serv., July 1978.

6. _____. Farmers' Use of Pesticides in 1976, AER-418, Econ. Stat. Coop. Serv., Dec. 1978.

7. _____. Agricultural Statistics: 1977.

8. _____. Dimilin Federal/State Assessment Team for Soybeans, 1978.

9. _____. Losses in Agriculture. AH-291, 1975.

*U.S. GOVERNMENT PRINTING OFFICE: 1979 280-931/ESCS-147

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF
AGRICULTURE
AGR 101
THIRD CLASS

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife -- if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.